

# Manufacturing Systems Engineering

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## College of Engineering

The Department of Mechanical Engineering at the University of Kentucky provides an intellectually challenging environment in which to pursue advanced studies and engage in research. In addition to programs of study leading to M.S. and Ph.D. Degrees in Mechanical Engineering, the Mechanical Engineering Department also offers a master's degree program in Manufacturing Systems Engineering. Students in this program are able to earn their degree entirely online or by taking a combination of courses offered online and in the face-to-face mode.

Graduate degree programs in the field of manufacturing systems engineering are important for enhancing manufacturing productivity and quality in the U.S. The Master of Science in Manufacturing Systems Engineering is designed to equip the student for opportunities in modern manufacturing processes and systems. Some of the possible areas of concentration for research and study are: Manufacturing Processes and Equipment, Design for Manufacturing, Plastic and Polymer Processing, Electronics Design and Manufacturing, Computer-aided Design and Manufacturing, Manufacturing Systems Planning and Control, Automated Assembly, and Lean Manufacturing.

The UK Center for Manufacturing, a part of the College of Engineering, conducts graduate-level academic research of the highest quality and transmits that knowledge to industry and government. Housing a 68,000-square-foot building, completed in the fall of 1989, the Center contains: R & D laboratories and offices including machining research lab, metrology lab, rapid prototyping lab, electronics assembly lab, welding lab, automation equipment lab, CAD/CAM/CAE lab, instructional TV classrooms, and TV satellite uplink and downlink equipment.

### **Admission Requirements**

Applicants normally have a bachelor's degree in engineering from an ABET accredited institution (or equivalent). For students with an undergraduate degree other than engineering, completion of a set of identified courses (or their equivalent) in an Engineering discipline will be required prior to admission to the program with full graduate standing. If a student does not meet these criteria, an evaluation of the student's overall education and experience may allow admission, subject to evaluation by the Director of Graduate Studies. GRE scores are NOT required for admission to the Manufacturing Systems Engineering MS program. However, applicants must note that, GRE scores must be submitted if they are interested in being considered for any graduate fellowships. .

### **Curriculum & Degree Requirements**

The Plan A provides for study and research leading to the degree of Master of Science in Manufacturing Systems Engineering. The thesis plan requires twenty-four credit hours of course work and a thesis. All students will be required to complete four specified core courses [MFS 606, MFS 605, MFS 505, MFS 613 (MFS 611, if enrolled prior to Spring 2016)]. The electives for each student will be developed in conjunction with an advisor to insure that the program provides breadth and depth of content for the student, and meets his or her specific needs and interests. Appropriate electives are drawn from areas of Engineering, Computer Science, Business and Economics, or Mathematics. Two electives are designated as Manufacturing Specialization electives.

The Plan B (non-thesis option) is reserved for students who have significant engineering research or development experience in a manufacturing environment, for which completion of a thesis would be less beneficial than the additional course work involved in Plan B. The Plan B requires thirty (30) credit hours of course work and the satisfactory completion of a final examination. All students will be required to

complete four specified core courses [MFS 606, MFS 605, MFS 505, MFS 613 (MFS 611, if enrolled prior to Spring 2016)], as well as MFS 784 Research Project in Manufacturing Systems Engineering, nine credit hours of Manufacturing Specialization electives, and nine credit hours of other appropriate electives. Approval of the student's advisor and of the Director of Graduate Studies is necessary for a student to pursue Plan B.

### **Course Descriptions**

#### **MFS 501 MECHANICAL DESIGN WITH FINITE ELEMENT METHODS. (3)**

This course emphasizes mechanical design techniques based on the finite element method, using machine design background as the starting point. Techniques for modeling machine elements will be shown in relation to the basic FEM theory. Emphasis will be on quantifying loads, the resulting stress and deflection, and relating them to design allowables, leading to an acceptable design solution. Prereq or concur: Engineering Standing, ME 344 and ME 205; or Graduate standing or consent of instructor. (Same as ME 501.)

#### **MFS 503 LEAN MANUFACTURING PRINCIPLES AND PRACTICES. (3)**

This course will introduce students to the fundamental concepts of production improvement utilizing lean manufacturing principles and practices. In addition to the lectures, web-based simulations/experiments/games will be used to help learn the application of the tools supported by industry case studies. A Capstone Simulation will be used to demonstrate the collective application of all the tools and techniques (details included below). An application project is also included where students will work in teams to study a real-life manufacturing or service environment to assess the current state, identify improvement opportunities and develop countermeasures for implementation. Prereq: Engineering standing or with instructor permission. (Same as ME 503.)

#### **MFS 505 MODELING OF MANUFACTURING PROCESSES AND MACHINES. (3)**

This course is aimed at providing the undergraduate and graduate students in mechanical and manufacturing engineering basic knowledge and understanding of the major manufacturing processes for modeling, monitoring and control of these processes through a series of analytical and experimental techniques and tools, including group work for assignments and experiments. Prereq: EM 302, EM 313, and engineering standing; or graduate standing with instructor consent. (Same as ME 505.)

#### **MFS 507 DESIGN FOR MANUFACTURING. (3)**

This course will provide a strong foundation in the concepts, theories and applications of design engineering methodologies for effective manufacture of high quality products at low costs and high productivity. In addition to the lectures, the assembly and design analysis of "product based assembly kits" will be used to apply and help learn the tools presented in class. The final project includes the application of these tools to re-design a given product from a manufacturing and assembly perspective. Prereq: ME 344 or instructor permission. (Same as ME 507.)

#### **MFS 509 LEADERSHIP FOR A LEAN ENTERPRISE. (3)**

Perhaps the most difficult part of a so-called "lean" transformation is to establish an appropriate culture which is greatly influenced by actions of leadership. The goal of leadership is to foster the creation of a culture which allows team member engagement and drives continuous improvement focused on creating the highest value for the customer. This is accomplished by developing a 'True Lean' operational environment in which the group by themselves uses systematic problem solving to improve the work they do to help meet the organizations' targets and goals without the need for direct management involvement. The challenge is to understand how this can be accomplished. This is a distance learning course designed to provide an introduction to important leadership thinking and activities required to create and sustain a lean culture within an organization as practiced by Toyota. The primary content for this course comes

from the internationally recognized University of Kentucky Lean System Program's public Lean Executive Leadership Institute and Lean Certification courses. In addition to weekly presentations by experienced Toyota executives and others, there will be weekly activities/ discussions designed to explore each topic in more depth. Topics will include: understanding the True Lean destination and core thinking, management led problem solving, understanding the path to True Lean, and developing a vision and strategy to achieve it. Other important topics discussed include the pillars of a lean business philosophy, the people side of lean, lean system operations management structure and measurement systems that support and sustain an ongoing lean transformation. Prereq: Student Lean Certification, or MFS 503 (Lean Principles and Practices), or MFS 526 (Lean Operations Management), or consent of instructor.

#### MFS 512 MANUFACTURING SYSTEMS. (3)

This course introduces students to fundamentals of design, planning and control of manufacturing systems aided by computers. Concepts of control hardware, NC programming languages, software aspects related to NC manufacturing, programmable controllers, performance modeling of automated manufacturing systems, group technology and flexible manufacturing systems, etc. will be addressed. Prereq: Engineering standing. (Same as ME 512.)

#### MFS 513 MECHANICAL VIBRATIONS. (3)

The analysis of vibrational motion of structural and mechanical systems. Single-degree-of-freedom systems; free vibrations; nonperiodic excitation; harmonic excitation. Modal analysis of multiple-degree-of-freedom systems. Vibration of continuous bodies, including strings and bars (axial, torsional and flexural modes). Energy methods. Prereq: EM 313 and EM 302, engineering standing or consent of instructor. (Same as ME 513.)

#### MFS 515 ROTORDYNAMICS OF TURBOMACHINERY. (3)

Review of dynamic characteristics unique to high speed rotating shafts in turbomachinery. Equations of motion for a rotor, including gyroscopic effects; computational methods, including finite element; effects of bearings and nonlinearities, stability; application to design situations in high-speed equipment, including aerospace, energy generation, and other industrial applications. Prereq: EM 313 and Engineering standing; pre/co-requisite for Western Kentucky University students: ME 415 and ME 344; pre/co-requisites for UK students: ME 344 and ME 501; or Graduate Standing or consent of instructor. (Same as ME 515.)

#### MFS 520 INDUSTRIAL AUTOMATION AND CONTROL. (3)

Automation techniques for controlling equipment and processes, including applications of sensors, transducers, motor starters, variable frequency motor drives, linear actuators, and proportional hydraulic valves. Ladder logic programming of programmable automation controllers (PACs) and programming human-machine interface (HMI) touch-screen panels. Prereq: Engineering standing or permission of the instructor. (Same as MNG 520.)

#### MFS 523 CONCEPTS, ASSESSMENT TOOLS AND METHODS IN SUSTAINABLE POWER AND ENERGY. (3)

A multidisciplinary course presenting an overview of key topics in sustainability and environmental impact assessment for engineers. Topics will include assessment of current and future energy systems, renewable and conventional energy technologies, supply chain management, sustainability metrics, energy assessment tools, environmental impact assessment and life cycle assessment. Topics will be presented and their attributes described within a framework that aids in evaluation and analysis of energy technology systems and designs in the context of political, social, economic, and environmental goals. Prereq: Engineering Standing and Senior Classification or Consent of Instructor. (Same as CME/EGR 523.)

### MFS 525 ORGANIZATIONAL LEARNING FOR LEAN MANUFACTURING. (3)

Learning organizations are skilled at creating, acquiring, and transferring knowledge, and at modifying their behavior to reflect the new knowledge and insights. In this context, this course will discuss leadership styles, adult learning principles, communication, organizational behaviors, and a structure for learning. Prereq: MFS 503 or consent of instructor.

### MFS 526 LEAN OPERATIONS MANAGEMENT. (3)

This course will cover topics in basic lean system operations as well as the management system to support the attainment of highest customer satisfaction with respect to Safety, Quality, Cost, Productivity, Delivery and Human Resource Development. Working in teams, students apply fundamental lean tools and concepts to develop a lean operations environment capable of driving continuous improvement in a simulated factory. As the operational environment evolves, key management principles and tools are explored using the teachings of Taiichi Ohno and others considered to be the pillars of the Toyota Production System. All students must have a webcam and microphone or headset to participate in on-line team and class meetings. Prereq: Enrollment restricted to junior-level or above students. Prior enrollment in the Lean Student certificate course or MFS 503 is required or with the consent of the instructor. (Same as EE 526/ME 526.)

### MFS 541 OCCUPATIONAL BIOMECHANICS. (3)

This course will provide an understanding of physical interaction between workers and their tools, machines, and materials so as to enhance the workers performance while minimizing the risk of musculoskeletal disorders. Discussion of ergonomic methods for measurement, assessment, and evaluation, with major topics including manual materials handling, cumulative trauma disorders, environmental stresses, safety, and legal issues. Prereq: Engineering standing or with instructor permission. (Same as BME 541.)

### MFS 554 CHEMICAL AND PHYSICAL PROCESSING OF POLYMER SYSTEMS. (3)

Theory and practice as related to the chemical and physical processing of polymer systems. Polymer rheology, heat transfer in polymer flows, polymer engineering properties. Polymer processing operations and materials selection; flow instabilities. Prereq: CME 330, CME 425 or ME 325; or consent of instructor. This course is open only to graduate students or undergraduates with engineering standing. (Same as CME/ME/MSE 554.)

### MFS 556 INTRODUCTION TO COMPOSITE MATERIALS. (3)

Modern composite materials and their applications. Basic concepts and definitions. Fundamental properties of fibers and polymer resins. Manufacturing methods. Analysis and design of laminated and chopped fiber reinforced composites. Micro- and macro-mechanical analysis of elastic constants. Failure theory of composite materials. Computational design of composites. Prereq: Engineering Standing, and EM 302 or with instructor permission. (Same as CME/ME/MSE 556.)

### MFS 599 TOPICS IN MANUFACTURING SYSTEMS ENGINEERING (Subtitle required). (3)

A detailed investigation of a topic of current significance in manufacturing systems engineering such as: computer-aided manufacturing, special topics in robotics, and lean/agile manufacturing. May be repeated under different subtitles to a maximum of six credits. A particular topic may be offered at most twice under the MFS 599 number. Prereq: Variable; given when topic is identified.

### MFS 603 MANAGEMENT FOR A LEAN SYSTEM. (3)

This course provides the MFS student an opportunity to develop skills in managing a lean system at the 'shop floor' level. MFS 605 MODELING, SIMULATION AND CONTROL FOR MANUFACTURING. (3)

The purpose of this course is to examine methods and systems from the perspectives of modeling, simulation, and control of manufacturing facilities. The emphasis will be primarily on techniques that can be used to model and evaluate performance of systems. Students are encouraged to think critically about available technologies, identify relative strengths and weaknesses, and analyze the technologies toward developing improved solutions to factory control and information management problems. Prereq: Graduate Standing. (Same as EE/ME 605.)

#### MFS 606 GLOBAL ISSUES IN MANUFACTURING. (3)

The need to increase quality, productivity, efficiency and sustainability in manufacturing operations spanning the product, process and systems (manufacturing systems as well as supply chain) domains is essential for companies to be successful. The increased globalization of markets and manufacturing operations, declining natural resources and negative consequences of some manufacturing practices as well as increased legislation in many regions has led to many new challenges that companies must overcome to be successful in competitive markets. This seminar course will introduce students to a variety of global issues in manufacturing through presentations by leading national and international experts in these domains. The seminars will cover a broad range of manufacturing related topics relevant to many disciplines including manufacturing, mechanical and electrical engineering. The course can also help graduate students identify topical issues that need further investigation and could become potential research topics. (Same as EE/ME 606.)

#### MFS 607 ANALYSIS OF METAL CUTTING PROCESSES. (3)

Advanced study of metal cutting involving the mechanics of metal cutting including cutting forces, tool-wear/tool-life and temperature analysis, surface finish and integrity, chip control, machinability assessments and advances in cutting tool technology. Prereq: ME 505. (Same as ME/MSE 607).

#### MFS 611 MANAGING EFFECTIVE ORGANIZATIONS. (3)

A critical examination of behavior and performance within organizations and between organizations. Special attention is paid to the problem of performance at the individual, group, and formal organizational level. (Same as MGT 611.)

#### MFS 612 DESIGN OF LEAN MANUFACTURING SYSTEMS. (3)

Technical design of manufacturing systems in accordance with lean manufacturing principles. Topics include models for characterization and analysis of factory flow dynamics, production flow analysis, work cell design, and design of pull-based production control systems. Prereq: MFS 503 Lean Manufacturing Principles and Practices.

#### MFS 613 SUSTAINABILITY, ETHICS, AND LEADERSHIP IN MANUFACTURING ORGANIZATIONS. (3)

This course is intended to provide future manufacturing managers and leaders a basic understanding of important theories and practices necessary to successfully manage and lead teams to achieve manufacturing organizational objectives. The course is organized into several modules. The first module will focus on developing an understanding and capability to approach ethical and sustainability concerns confronted by manufacturing organizations. This will include coverage of tools to help identify and address societal and environmental obligations of manufacturing organizations and issues confronting them that span multiple cultures and nations. Because people are one of the most important resources in any organization, the second and third modules will address organizational behavior (OB) and individual effectiveness. OB theories and practices that can be used to increase the capability to observe, understand and manage people's behavior will be covered. The last module considers safety and ergonomics as they

relate to manufacturing organizations. Coverage will include tools and techniques that can be used to analyze the manufacturing workplaces and ensure its ergonomic design as well as an overview of the current state of occupational safety and health regulations. Prereq: Graduate standing.

**MFS 681 SUSTAINABLE QUALITY SYSTEMS DESIGN. (3)**

This course provides the theory and principles of sustainable quality production systems as originally developed by Shewhart and Deming. The course will focus on statistical methods from the viewpoint of quality control: at the product specification level; at the product production level; and at the judgment of quality at the inspection level. Prereq: Basic statistics.

**MFS 699 TOPICS IN MANUFACTURING SYSTEMS ENGINEERING (Subtitle required). (3)**

A detailed investigation of a topic of current significance in manufacturing systems engineering such as: computer-aided manufacturing, special topics in robotics, and lean/agile manufacturing. May be repeated under different subtitles to a maximum of six credits. A particular topic may be offered at most twice under the MFS 699 number. Prereq: Variable; given when topic is identified.

**MFS 748 MASTER'S THESIS RESEARCH. (0)**

Half-time to full-time work on thesis. May be repeated to a maximum of six semesters. Prereq: All course work toward the degree must be completed.

**MFS 768 RESIDENCE CREDIT FOR MASTER'S DEGREE. (1-6)**

May be repeated to a maximum of 12 hours.

**MFS 780 SPECIAL PROBLEMS IN MANUFACTURING SYSTEMS ENGINEERING. (3)**

This course involves specialized individual work in manufacturing systems engineering. Prereq: Approval of instructor.

**MFS 784 RESEARCH PROJECT IN MANUFACTURING SYSTEMS ENGINEERING. (3)**

This course involves individual study related to a special research project supervised by the instructor. A full written report on the project is required.

